SIT792 - MINOR THESIS

FINAL THESIS REPORT

UNIT CHAIR – Dr. Shui Yu

SUPERVISOR - Dr. Atul Sajjanhar

Submitted By – Sahil Deshpande

Student ID - 215168645

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Abstract –

Internet of Things (IoT) has made incredible contributions in the field of information technology. With the use of Internet of things (IoT) most devices are now capable of functioning large operation in less amount of time. One important application of Internet of Things is 'Arduino Board' which can be connected to internet by utilizing various web-services. Arduino board can be used with several sensors to record the data. With Arduino board, we can extract sensor data instantly and examine it for our needs. With the invention of Arduino board, the use of sensor was increased and was used to get a structured data for number of environmental parameters every day. The sensor data is mainly used in farming, weather stations, hospitals, schools, governmental organizations and so on. Data can be used for monitoring traffic; some organizations use data for certain parameters to optimize the quality of life. Sensor data can be useful to monitor air, water, temperature, quality of soil. In this research, I have proposed the idea of 'Cloud Connected IoT' by using Arduino Yun board and DHT22 Temperature and Humidity sensor. I have demonstrated the use of Arduino board to measure temperature and humidity. The data is obtained from the sensor and is stored into cloud platform, Dropbox in form of .csv file. A front-end webpage is designed to display the real-time temperature. This is a good idea to obtain temperature and humidity readings at your convenience.

Keywords – Arduino Yun, DHT22 Sensor, Weather Station, Internet of Things (IoT).

Chapter – 1

Introduction –

In old times, there was no means to measure the weather parameters but with the passage of time and advancement in technology, scientists have developed various methods to measure and record various weather parameters such as temperature, humidity, air pressure, etc. Nowadays, plenty of applications, devices and websites provide latest information about the weather where the data is updated every second which is possible due to internet. The weather stations/devices/sensors are connected to internet using various web services and hence the recorded parameters are displayed on websites and applications. In this project of Cloud connected Weather Station, temperature and humidity parameters are measured by using Arduino Yun board with DHT 22 sensor and are uploaded to cloud which are further displayed in a front-end webpage.

The Internet of Things is a concept which is based upon connecting multiple devices to the internet that further it facilitates communication between them and their management. Devices are mainly small microcontrollers and embedded processors, which can perform these critical tasks. Many applications tend to process data locally before processing it over the network. (Fazackerlry F, Huang E, Douglas G, Kudlac R, Lawrence R (2015)) have forecasted that IoT will expand from 30 billion to 50 billion devices by the end of this decade. The focus towards Internet of Things is empowered through 'Arduino computing platform'. This platform has simplified projects which permits users to build Internet enabled devices without any computer hardware and software skills. IoT's one of foremost requirement is the ability to connect and process data wirelessly. These devices have a potential to process large amount of data.

Among the microcontrollers, the AVR-based Arduino microcontroller is the most successful open source project and it is compatible with various other controllers based on its functionality, size and packaging. Arduino platform is accepted widely for physical computing. The Arduino coding language is based on the principles of C/C++ and it has its own programing environment which comprises of IDE (Integrated Development Environment). Arduino IDE is a powerful coding environment. Most of the user programs can be sketched easily and can be complied and uploaded for the controller board activities. Arduino board consist of sample programs for which reference guides can be found on Arduino website. The microcontroller of the Arduino Yun which is based on the 'ATmega32u4' chip and 'Atheros AR9331' processor. The processor is capable of supporting Linux-based distribution on OpenWrt called OpenWrt-Yun for Arduino Yun. The Arduino Yun board has inbuild support of Ethernet, WiFi, USB-A port, micro-SD

slot, a total of 20 digital input/output pins. 16 MHz crystal oscillator, micro USB connector and 3 reset buttons. For temperature and humidity readings DHT-22 sensor is used. The measurement of the humidity and temperature with by reported in a digital signal format. (Jindarat S, Wuttidittachotti P (2015)) (Koprda S, Balogh Z, Hruby D, Turcani M (2015)) (Kato Y (2010)).

This project mainly depicts an example of relation of Internet of Things (IoT) and Open Source hardware which is Arduino in this case. Both IoT and open source hardware are linked to each other which fulfills a basic requirement of the project. This makes the data gathering method more convenient by utilizing IoT. Also, the collected data is handled with an assistance from internet protocols, hence making this application useful in remote areas. Also, nowadays IoT has provided a huge market base for projects like this.

1.1 Scope of Topic –

The scope of the research is to demonstrate the method to get the temperature and humidity data with the help of Arduino Yun board and DHT-22 temperature and humidity sensor and store it on cloud. The data will be stored on cloud platform, Dropbox and it is presented using a front-end webpage. The main aim in this project is to smoothly obtain readings and store it over cloud without any errors. Further, a literature review is carried out with published research papers about the nature of Arduino board and other components and related activities.

1.2 Significance of Project –

Arduino board is capable of handling environmental sensor data. The main significance of the Hence we can determine the current temperature or humidity data easily without depending upon any other source. Earlier people had to rely over radio, news channels or newspapers for temperature readings. But now with this technology, anyone can obtain temperature data over phone, computer or other electronic device at their own convenience. This is a cost-effective process to find data and accurate too.

1.3 Background –

Earlier, describing and recording weather was based upon daily calculated patterns of weather which was highly imprecise. For example, people used to predict the weather for upcoming day by relying on the weather for present day. This experience started accumulating over the ages to predict weather on daily basis. This technique is based upon the estimations for gauging tomorrow's weather conditions based upon today's conditions. But with the evolution in technology, various instruments were invented in the late seventeenth century which would lead to precise measurement of temperatures. As the

technology, advanced different methods for collecting data and displaying it were operational by the end of twentieth century. Earlier, we didn't have websites and mobile applications displaying weather data but nowadays there have been development in both collection methods of weather data and visualization methods that display the data collected appropriately and precisely. Also, there has also been development in local weather stations that has range from few meters to few kilometers. These are quite helpful in calculating and recording the weather for particular local areas. The project, Cloud Connected IoT is based upon the idea of local weather station that records the temperature and humidity data for small range of area and uploads it to cloud based platform which is presented in form of webpage eventually.

1.4 Motivation –

The main motivation for developing a project related to Cloud Connected IoT was to record the local weather data. As we know that there are multiple methods to measure and get the weather details nowadays. But if we want to get data for local area precisely, then this project is quite helpful. It collects data by utilizing DHT22 sensor which is a temperature and humidity sensor. This sensor is connected to Arduino Yun Board which saves the data into cloud and is displayed in form of webpage. Also, Arduino Yun is IoT device that connects to internet via web services.

This document of thesis comprises of six chapters. The first chapter of this document is 'Introduction' that consists of brief discussion of topic, its scope and significance. Also, background of topic and motivation are discussed. The second chapter relates with the 'Key Related Research Review' that includes a strong evidence from literature regarding various proposed projects related to Arduino along with their data collection and data visualization methods. Additionally, a critical analysis of assessed literature is also included that discusses upon the limitations of existing methods. This part also puts a light on 'Research Problems and Questions' that are assessed using this project. The third chapter relates with the 'Implementation Methods and Methodology' and discusses the method used to complete the project of Cloud Connected IoT. It also deals with the hardware and software requirements along with the methodology used. Next chapter is 'Results' that discusses the results yielded after the implementation. Chapter fifth is 'Problem Analysis' that reviews the research problems and questions based upon our results. Lastly, chapter six represents the 'Conclusion and Future Research' related to the project.

Chapter – 2

Key Related Research Review –

The objective of this section is to examine and discuss the findings and data from the literature review. For this purpose, few reference papers and articles for the research report are selected that highlight the basic information about the Arduino board. Furthermore, some projects related to Arduino microcontroller board are discussed which are dependent upon different methodologies. Also, data collection and visualization methods of these projects are examined. Lastly, the limitations of existing systems are highlighted that leads to research problems and questions.

This paragraph mainly puts light on the evolution of Arduino board since it has been invented in 2005. The man behind its invention was Massimo Banzi who developed the very first version of Arduino. It was based on the Hernando Barragan's Wiring project. In this, the API's for Wiring were reused and Arduino was reimplemented from scratch which made Arduino open-source. The team had whole design for Arduino which lead to its first production that was used in workshops and classes. After that Arduino became self-marketing and made it way everywhere in the Internet (Severance, C (2014)). After that there has been different models of Arduino board, namely, Uno, Nano, Yun,
Due, etc. The table below shows some specifications of Arduino models –

Model	Processor	EEPROM [KB]	SRAM [KB]	Flash [KB]
Uno	ATmega328	1	2	32
Nano	ATmega168/ATmega328	0.512/1	1/2	16/32
Mega 2560	ATmega256	4	8	256
Leonardo	ATmega32u4	1	2.5	32
Due	AT91SAM3X8E	-	96	512

Figure 1 - Specifications of Arduino Models (Fazackerley, S, Huang, E, Douglas, G, Kudlac, R, Lawrence, R (2015))

2.1 Related Work -

This section of literature review discusses few projects of Arduino board that utilize various technologies and models. Also, the focus is laid on the data collection and visualization methods. The new wave of Internet of Things(IoT) has resulted in production of huge amounts of data from variety of resources

such as sensors networks, which should be classified and stored properly. (Sarangi, S, Kar, S (2013)) developed a new web-based repository known as Wisekar which is elaborated as Wireless Sensor Knowledge Archive. It is the integrated web repository for saving the sensor data from the IoT connected devices along with affluent data visualization capabilities. Its versatile nature can be identified from the instance that it can extend and fix-up the XML events that are based upon metadata and images. Usually, SOAP (Simple Object Access Protocol) and REST (Representational State Transfer) architectures are utilized for transmission of data via HTTP. Wisekar integrates with the REST service due to its flexibility to obtain and manage variety of data from the sensor. Data organization in Wisekar depends upon two types of datasets namely, passive sets and active sets. Also, Wisekar API is used to enter, update and delete the events from sensors. The data visualization with Wisekar is convenient as data collected in every active set is divided into large number of pages for easy retrieval. Also, when the data visualization is requested the data collected in displayed in form of CSV and XML formats (Sarangi, S, Kar, S(2013)).

The research by (Lee, S, Jo, J, Kim, Y, Stephen, H (2014)) presents the Arduino-connected sensors that uses REST-based web service for data collection, storage and visualization. Here, Arduino is set up on the Ethernet connection and the timer is configured using variable *setTimer.* The data is obtained using *getData()* and *getVoltage()* functions that depend upon the analog input signal to Arduino. Now, the collected data has information such as sensor ID, IP address and obtained value. This information is sent to server by using *restConnection()* which again sends the data to URL using REST architecture as REST-based web service can be used for remote devices as well. To visualize the collected data, Model View Control (MVC) pattern is selected to depict the output to client requesting information from Model. Here, data is displayed on third-party service of Google Charts in Scalable Vector Graphics(SVG) format (Lee, S, Jo, J, Kim, Y, Stephen, H (2014)).

As per the research carried out by (Yang, Q, Zhou. G, Qin, W, Zhang, B, Chiang, PY (2015)) focuses on the real-time air monitoring by using Arduino Yun. Arduino Yun platform acts as a bridge between server and client as it collects the data and sends it to Wi-Fi chip. As Arduino Yun board comes with an embedded controller that can also work in Linux. This is based upon OpenWRT framework which allows the user to operate the devices using Linux platform. Instead of making a firmware that is static and solitary, OpenWRT allows the user to access filesystem which is executable by using specific packages. This property is really useful in deploying a setup and application of our choice instead of deploying the developer's settings. All the packages are installed using specific bundles for specific applications (OpenWRT, 2015). To collect the data various sensors are used namely, temperature/humidity (PM10),

dust (PM2.5) and VOC sensors. The collected data of the sensors are sent to 10-bit Analog to digital Convertor of the microcontroller unit. The received data in controller is assessed and is forwarded to Central Processing Unit of Arduino Yun with the help of UART. As, we know that Arduino Yun does not have any built in large memory, so a SD card is used to save the measured sensor data. Also, a smart phone is required, that supports HTML 5.0 in its browser, to trace the data wirelessly on the webpage. It is connected to the Arduino Yun board wirelessly. The data is transmitted from the sensors to the MCU and is sent to Linux CPU through UART after verification which transmits the data to cloud using data logging in SD card. Hence, a webpage is developed to display the sensor data in real-time. The data is represented graphically on the webpage. This data can be accessed by any user connected to Wi-Fi (Yang, Q, Zhou. G, Qin, W, Zhang, B, Chiang, PY (2015)).

As per (Vagnoli, C (2014)) the air quality in a city is monitored by using framework called SensorWebBike. In this, a bike is equipped with Arduino Board and several sensors. It is a web-based mobile framework that is based on the sensing technique. Its main components are Arduino board based AirQuino, GeoDatabase of an area and web application. For AirQuino, several sensors are used with Arduino board that are of high resolution and are capable of measuring noise, temperature, humidity, CO, CO_2, O_3, NO_2 and CH_4. Also, accelerometer and globethermometer is used to measure quality of road paved and thermal comfort index respectively. The microchip unit incorporated in Arduino board obtains data from every sensor and investigations quick information from accelerometer and commotion sensor. The infrastructure of this system is composed of GeoDatabase utilized for data collection, management and storage, a GPRS for transmission of collected sensor data and a web application display the data collected. General Packet Radio Service (GPRS) transmits the sensor, which consists geolocated data related to surrounding environment and air quality, to the server linked with application. The flexibility of this system is assured from the fact that it uses open source Arduino platform and Open Data method. For the data visualization part, the data stored in GeoDatabase can be viewed via the web application that is developed using Java2EE. Data is displayed in tabular, geographic map or chart forms (Vagnoli, C, Martelli, F, Filippis, T, Lonardo, S, Gioli, B, Gualtieri, G, Matese, A, Rocchi, L, Toscano, P, Zaldei, A (2014)).

According to the research by (Costanzo (2013)), a framework is proposed which is low cost and is based on the GPS signals from Arduino in order to collect the information about traffic flow. This further leads to the computation of traffic map that is colored. Also, this system depicts the shortest path towards the destination depending upon present position. This framework consists of a map from Google Maps API

which helps in providing all the geo coordinates. It transmits the signal from the Arduino board with GPRS to the support center. Arduino board is used with GPS shield that tracks down the driver. This is so fast that it facilitates the server to compute various data. That information is about the distance, speed and stoppage time of the vehicle during travel (Costanzo (2013)).

As Per (Fazackerley, (2015)), unit has provided a library usage of main value storage factors to use for Arduino Devices. The explanation for is to give quality training to Arduino programmers, so they can control information with no issues like deploying data structures. There is an advantage in execution to process information to decrease the cost, due the availability and ceaseless information from the combined devices. The devices used for data collection usually have microcontrollers that can enhance device life and its utilization. But at the same time, it limits the memory and CPU resources. Be that as it may, even essential isolating and adjacent capacity limit can also upgrade the device's lifetime besides, imperativeness use while diminishing system information transfer limit. The utilization of database upgrades programmer's effectiveness as it gives information deliberation from information stroing and information querying. Through different capacity which is characterized in the library serves to interfaces it with the database (Fazackerley S, Huang E, Douglas G, Kudlac R & Lawrence R, (2015)).

As per the research by (Sugathan et al. (2013)), Arduino board is utilized to examine person's health by wearing the device. To accomplish this, the researchers designed a lab coat that is wearable and has sensors on it. Sensors used are SHT15 which is temperature sensor used to measure temperature of body, GSR sensor which is a galvanic skin resistance measuring sensor used to measure sweat from the body and Oximeter used to measure SPO_2 level in the body. Arduino sketch is used to record all the sensor data and the output from the sensors is displayed on the serial monitor of Arduino board. This data can be also displayed in form of graphs. The graphs represent the temperature, oxygen level and GSR. (Akshay Sugathan, Gaurav Gautam Roy, G.J Kirthyvijay, Jeffrey Thomson (2013)).

According to the research by (Chellappan et al. (2014)), There is utilization of Arduino along with the sensors to record the e-Health parameters such as temperature of body, oxygen level using oximeter. The data is recorded using Arduino board and displayed in the serial monitor window which is further represented using MATLAB platform. Outputs are presented graphically. This research is carried out on both males and females aged between twenty-one years to fifty -two years of age. Here data is displayed by using MATLAB (Chellappan, K, Zainee, NM 2014)

2.2 Critical Analysis –

This section of literature review will focus on the limitations of the above-mentioned methods. As clear from above research, Vagnoli et al. (2015) used the framework to capture the data from local area while the framework used by Yang et al. (2014) is used for indoor environment. The framework that former has implemented uses sensors that are connected to Arduino via GRPS and hence the data is saved to the GeoDatabase while the latter uses framework that connects three sensors with Arduino and saves the data on SD card via data logging. It is clear from this discussion that the SensorWebBike framework is more advantageous in term of storage of data. Also, the SensorWebBike covers large outdoor areas.

If the comparison is carried out between Costanzo et al. (2015) and Vagnoli et al. (2015), it's clear that their research area is entirely distinctive but they both utilize Arduino with GPRS to transmit the sensor data to the web server. There is a severe limitation in both methods that for proper implementation of SensorWebBike and Traffic flow framework there is a need of GeoDatabase and Google Map API's which are required to be bought and their prices are quite high. If someone wants to implement these frameworks for long time, then he/she might have to pay huge amount to obtain these basic requirements. Also, the upgradation of these requirements may cost a lot.

Also, the framework for data collection developed by (Sarangi, S, Kar, S (2013)) i.e. Wisekar is unreliable for large amounts of data. The framework developed by (Lee, S, Jo, J, Kim, Y, Stephen, H (2014)) uses Ethernet connection less reliable.

Both (Chellanppan et al. (2014)) and (Sugathan et al. ((2013)) discuss about health examining by using the Arduino board. Both the researchers have used almost the same sensors to monitor various parameters of health such as body temperature, oxygen level of body and so on. As clear from the above discussion that (Sugathan et al. ((2013)) have developed a system which has all the sensors and Arduino board attached to the lab coat while (Chellanppan et al. (2014)) uses devices directly. The former has represented the outputs using graphical representation while the latter one has depicted the output by using MATLAB. Moreover, it is more convenient to use MATLAB for graphical representation of Arduino data as it is more precise and accurate.

2.3 Research Questions and Problems –

This area mainly focuses on the identification of major research problems and challenges that are faced during research. The main aim was to identify all the challenges and problems and find mitigation

techniques so that all processes run smoothly. Let us briefly look at each problem and try to find solutions for them.

- Identification of appropriate tool to record sensor data -

  To record data from Arduino board is a big task. In this scenario, the Arduino is to be connected to the sensor and then is to be connected to google cloud platform, i.e. Dropbox. After some research, I found 'Temboo web service' as the primary solution for this problem. But It is not free.

- Connecting Arduino board wirelessly-

  After the cable connection of Arduino, the aim was to connect Arduino wirelessly. It is bit difficult to connect Arduino for the first timers. It requires more authentication and internet connections without any proxy settings.

- Applying programing techniques on Arduino -

  For some basic Arduino projects, we don't require prior programming knowledge. To get the readings in google cloud we need to modify the Arduino sketch with logic and programming script.

- Choosing external storage device on Arduino to store data-

  To mount a large amount of data on Arduino, sometimes we need external storage device. Hence SD memory card can be a good option. It comes with larger memory space and long lasting life. Arduino board consists of a memory card slot.

  In addition to the above-mentioned problems, there are some minor obstacles are present. This project of cloud connect IoT requires extensive research as there are limited resources available. Not many Arduino projects are deployed using cloud technologies. The data in the literature review does not provide sufficient guidance to connect and upload data in Google cloud. We need to consult experts or use programming knowledge to implement and execute the code.

Chapter – 3 –

Implementation Method –

This section of Minor Thesis document deals with the implementation of the Cloud Connected IoT framework. This section clearly specifies the fundamental requirements of the project, system design of the project and the working of Cloud Connected IoT framework. The project requirements are further divided into hardware and software requirements. The project overview mainly includes the information about Arduino Yun board, Arduino Sketch, Cool Term and Dropbox. The system design and working relates with the method used along with its working. All the details are explained with the help of screenshots wherever required.

3.1 Project Requirements –

This research project mainly involves measuring the temperature readings and later storing it on to the google cloud. Hence it would require various physical devices and software. The requirements of this project can be broadly classified as Software requirements and hardware requirements. Hardware is the physical part of the project on which the implementation of the project is done. Whereas through software we can interact with the system to get results. Below are some details related to both -

3.1.1 Hardware Requirements –

Hardware i1s the physical part of the project on which the implementation of the project is done. In this project, we have used certain hardware devices to execute various tasks such as collecting temperature readings, connecting power supply to all the devices, connecting Arduino board with DHT-22 temperature/ humidity sensor with connecting wires, transferring data to the system and more. These hardware equipment needs to be connected to make a combined working system. The hardware equipment used in this project are:

- Arduino Yun Board
- DHT-22 sensor
- USB cable (serial connections)
- Connecting wires
- Power supply (Power bank)
- Computer system

All the hardware devices should be connected in suitable pattern defined in the instructions to obtain the expected output. To make these devices work we need few software applications which will be discussed in the below section.

3.1.2 Software requirements:

Software is the set of instructions, which the physical devices, hardware requires in order to execute. In this project, we should write set of codes to help Arduino board to get connected with DHT-22 sensor. Also, we need a good programming code to design the front-end webpage, to display the environmental sensor data from drobox. I am using Coolterm application software to store data in the dropbox from Arduino. So, let us shortlist all the main softwares used in this project.

- Arduino IDE
- DHT sensor code
- CoolTerm (application)
- Web Browser (to host the data)
- Dropbox (to store the data)
- Webpage (to display the data)

3.2 Project Overview

The main aim of the project is to design a cloud connected weather station, which can provide quick access to the real-time temperature and humidity data. Moreover, it would be convenient for the users to prepare analysis of temperature data at different time intervals. This is possible after the right use of all the components used in the framework. So, let us look at all the components of the system.

3.2.1 Arduino Board:

Arduino is an open-source electronics platform easy to use hardware and software platform. To operate Arduino board, we need to use Arduino programming language on Arduino software IDE which is also an open source application. Over the years Arduino has proven vital in executing everyday projects using complex scientific instruments. Arduino software is easy to learn for the beginners, also experienced people can manipulate it into some meaningful programming code. Some of the benefits of Arduino include:

- Inexpensive: Arduino boards are very cheap as compared to other devices.

- Cross-platform: Arduino has an ability to run over different platforms such as windows, Macintosh, OSX and Linux systems.
- Easy Programming environment: Arduino is easy to use for beginners and it is flexible for the people who are advance users.
- Open source and extensible software: For Arduino, the software contains open source tools which are available for extension by experienced programmers.
- Open source and extensible hardware: Under creative commons license, plans of Arduino are published. This enables the experienced coders to design their own module, extending it and improving it (Arduino Board Introduction, 2017).

3.2.2 Arduino Yun Board:

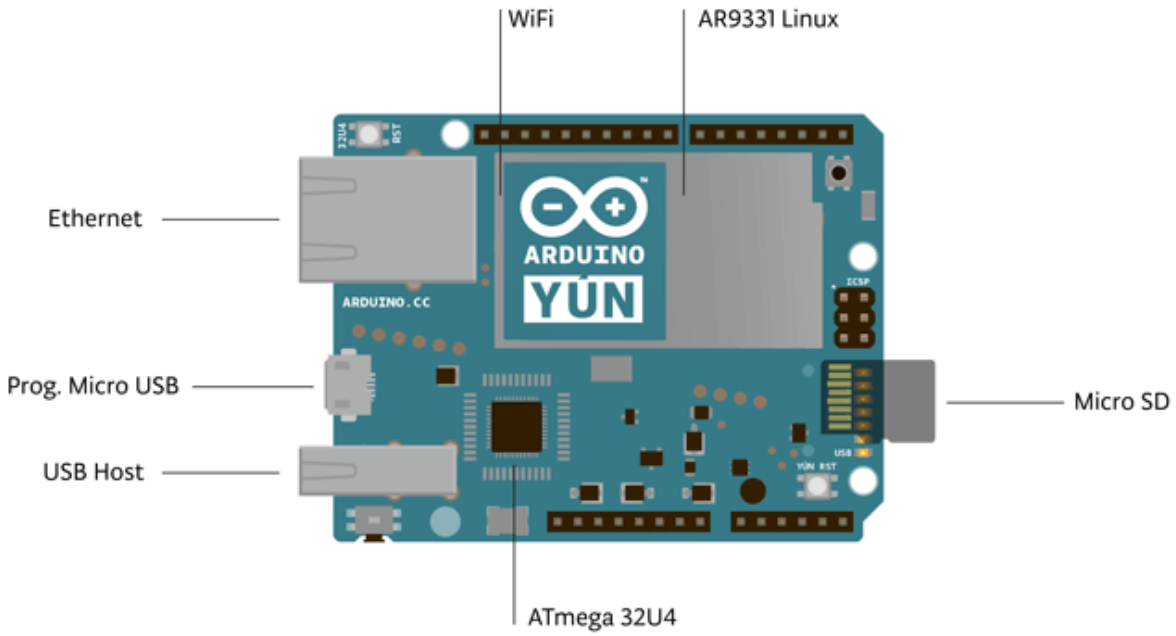

Figure 2- Arduino Yun Board

In this project, we have used Arduino board to get the sensor data from the DHT-22 humidity and temperature sensor. This Arduino Yun board has two processors which are 'ATmega32u4' and 'Atheros AR9331'. The Atheros processor is responsible in providing stability in Linux based program connectivity. The Arduino Yun board has several options in order to connect several external devices. This board has a built-in Wi-Fi port. It can also get connected with Ethernet wire by using the USB port. This board contains 20 digital input/output in which 7 pins can be used as PWM outputs and 12 pins can be used as

analog inputs. It has 16 MHz crystal oscillator, USB connection, a slot for micro-SD card, ICSP header, 3 reset buttons and more. (Arduino Guide (2017)).

Now let us see one by one all the components of Arduino Yun board.

1. Arduino programming language:

   The programming language which is used to code in Arduino IDE, which makes the Arduino devices function is known as Arduino programming language. Arduino programming language is closely related to C/C++ programming language. These languages should be used by the programmer in Arduino IDE to make the other sensor devices connected with connecting wires, work. Arduino IDE contains some build-in example of code which can be used by the programmers.

2. Micro-controllers:

   The above mentioned two micro-controllers which are 'ATmega32u4' and 'Atheros AR9331' helps Arduino to establish connections with OpenWRT and Linux systems. ATmega32u4 is responsible to upload the code into serial monitor which is independent with the hardware devices and is associated with the bootloader.

3. Power:

   The recommended power supply for the Arduino microcontroller is 5V. The Arduino board is not designed with an external regulator to control the voltage. The power is supplied through the 'Vin" pin.

4. Memory:

   For the micro-controller 'ATmega32u4', 32KB memory is present and 4KB is reserved for the bootloader. It has EPROM of size 1KB and SRAM of size 2.5KB. Arduino Yun board has less memory space hence it is recommended to store data in external devices such as micro-SD card or computer, cloud and more.

5. Input and Output pins:

   There are many pins on the Arduino board but we will focus on some of the pins which are important. For the input and output pins we have Serial 0 and serial 1 pin which is also known as RX and TX. When Serial 0 pin is receiving the data, the Serial 1 pin transmits the data. To indicate the power level of the

board, LED13 is used. If the LED is on, then it is assumed that high power is supplied if the light is off no power is supplied. Let us look with a diagram, how the main lights look on the Arduino board.

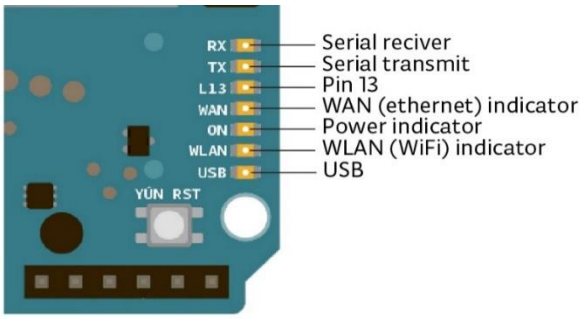

Figure 3- Input and Output Pins

6. Reset Button:

There are three reset buttons on the Arduino board. These three buttons are in the different regions of the board. These three reset buttons are better known by their name 'Yun RST', '32U4 RST' and 'WLAN RST'. Let us check the positions of these buttons in the diagram.

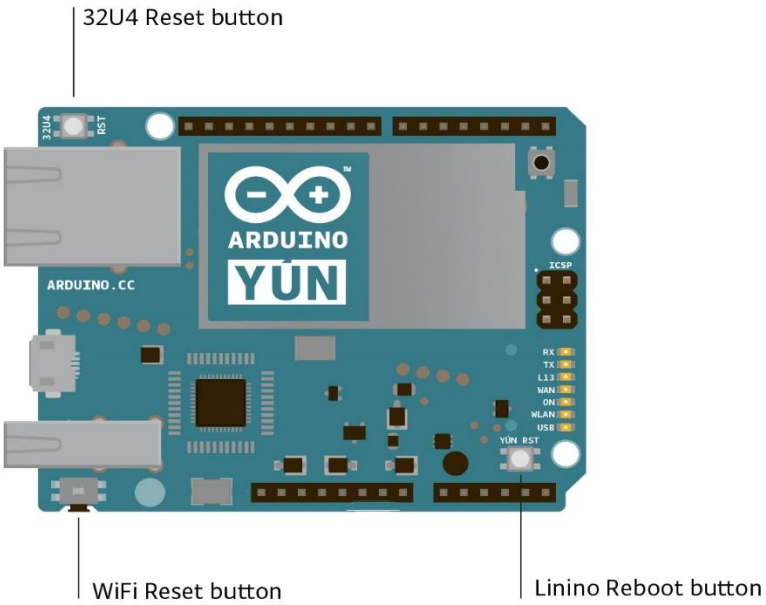

Figure 4 - Reset Buttons on Arduino Yun

All these components are built in features of the Arduino Yun board. So, for my project I have used Arduino board along with DHT-22 temperature/humidity sensor to get the temperature and humidity readings and store it on the Google cloud. Let us look at some of the other tools of this project which allows us to collect the data and store it.

1. Sensors:

   Sensors as the name suggests, have an ability to measure the change in the surroundings. It can sense the change in temperature, water, soil, environmental changes and many more. In this project, we have used DHT-22 sensor, which is the temperature and humidity sensor. In Arduino, we must type a sketch in the Arduino IDE. We can get the sketch from the examples in Arduino IDE.

2. Arduino IDE:

   Arduino IDE is an Arduino Integrated software development environment in which we can execute all Arduino sketches. It is open-source and compatible over Macintosh, windows and Linux. This is designed using Java and it relies over another open source softwares.

3. Arduino Sketch:

Arduino sketch are the set of codes which are used to run the Arduino board and other corresponding devices. Arduino sketch is executed on Arduino IDE. Arduino IDE contains various sample Arduino Sketches, of some common Arduino applications. DHT-22 sensor code is one of the stored sketches (Arduino Yun Board Guide, 2017).

3.2.3 CoolTerm:

CoolTerm is an application which allows to interchange the data with Arduino or other softwares with serial ports. It is a serial port terminal application. In this project, CoolTerm offers assistance in capturing the temperature and humidity data from Arduino IDE to Dropbox i.e. Google cloud. This is an open-source application, which less storage space. Let us look at some of the features of CoolTerm.

- CoolTerm has a capacity to handle multiple concurrent connections if multiple serial ports are available.
- It can display the received data in multiple formats such as text or hexadecimal format.
- It can send data via keypress and send string dialog which can support data in text or hexadecimal format.
- Data can be pasted into text format in the terminal window.
- It can send text files.
- It can record the received data.
- Local echoing of transmitted data.
- Local echoing of received data.
- Flow control in hardware and software
- Status indicators (CoolTerm, 2017).

3.2.4 Dropbox

To store the sensor data from Arduino, I have used dropbox as the cloud platform. It is very convenient to store the sensor data from Arduino IDE to dropbox by using CoolTerm. The main advantage of using dropbox is that, whenever u create any account over dropbox or you install dropbox, it creates a drive on your system and thus it becomes very simple to store the data. The drive acts like a cloud server and publishes real-time data on the dropbox cloud. Let us know more about Dropbox.

Nowadays there are many cloud technologies to store the data. One of which is Dropbox. This is a method from personal cloud storage. This is referred to as a method to store back up files on to the cloud. In addition to storing files, we can share or view other colleague's data, pictures and other files. Users can store their presentations and present when they are on board using dropbox.

Advantages of dropbox:

The main advantage of the dropbox is that it is completely free. There are no hidden or upfront costs associated with it. When any new user get registered to dropbox, he gets 2 gigabytes of storage space. However, we may find some alternatives to increase storage space. Some of the common methods to increase the storage space includes sending a fan mail, connecting dropbox to social media, inviting other people to join dropbox and more. Dropbox is very simple and convenient tool to learn for beginners. Anyone can get registered or understand it. It has a very simple user interface. There are various online tutorials for dropbox. Users can share files using dropbox. We must place the designated file in the folder and share another users ID.

Dropbox has certain limitations. Like other cloud services, security concerns are also related to dropbox. It states it has free services, but in future companies may change their policies. In dropbox users cannot perform encryption algorithms.

Overall dropbox is a good and handy tool to store data. It is possible to save real-time data in dropbox for free without using any external services (Acitodg, 2015).

3.3 System Design

This section will elaborate the outline and clarification of working system, how each single unit coordinates with each other to build up the System, with the assistance of charts and circuit graphs.

In this project, we have to make a cloud connected weather station with Arduino Yun Board, It known that Arduino is an open source equipment which can be customized by the need of software engineer and the program or outline can be executed through the Arduino IDE and it

actuates the Arduino Yun to perform as indicated by the sketch, which includes capture of Temperature and Humidity data with sensor DHT22 according to need of the project, which can be visualised through web program with help of web applications.

Arduino Yun Block diagram

Thee Arduino Yun board is embedded with Linux OS, wireless WAN and other micro-controllers. Let us look how the block diagram looks. We will be able to better understand the term with block diagram.

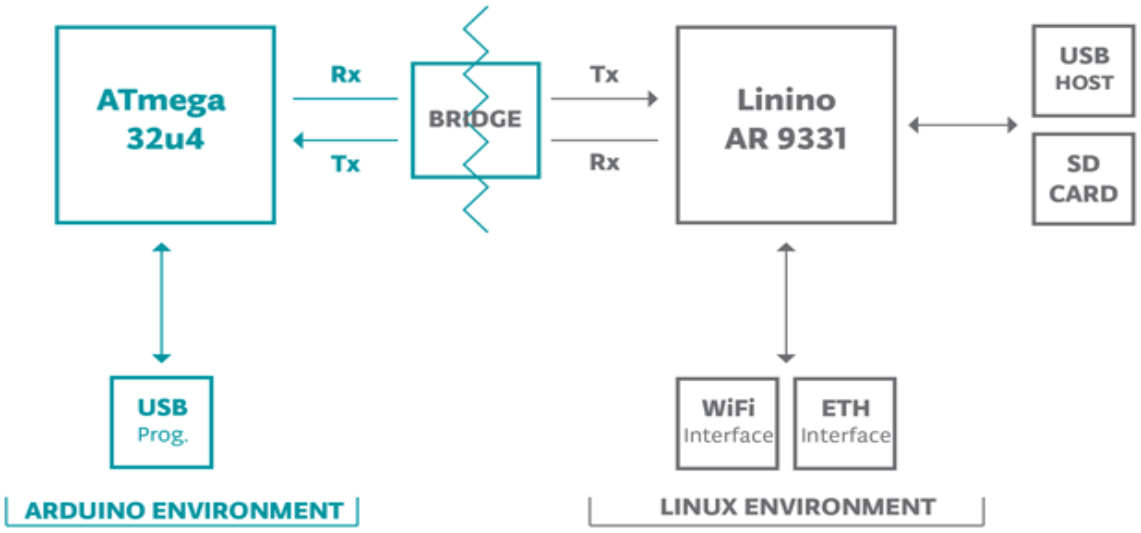

Figure 5- Arduino Yun Block Diagram

Arduino Yun Board with DHT-22 Temperature and Humidity Sensor

Figure 6- DHT22 Temperature and Humidity Sensor

Arduino Yun is perfect with each sensor and here in our project we are required to quantify the temperature and the humidity with the DHT22 sensor. DHT22 which is otherwise called AM2302 adjusts the yield as digital signal. It is little in size, expend low power and 100m transmission range. It is a stuffed in a case with 4 pin which make it simple to utilize.

The four pins of the DHT22 are VDD pin for power association which is not more than 5V, Data pin is for transmission, GND pin, which is to give the ground to the sensor and the last pin is not associated.

For the connectivity of the Arduino Yun we must insert the VDD wire pin 1in the 5V power supply of Arduino. Pin 2 data in digital pin 2 and GND pin 4 in power GND section of the board.

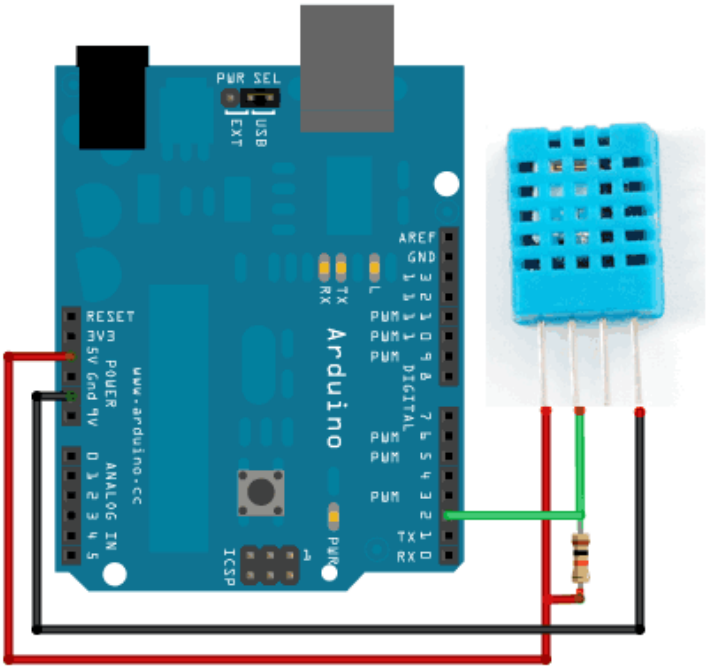

Figure 7- Connectivity of Arduino Yun with DHT22

After we have consolidated entire hardware parts, we should commence applying programing techniques on Arduino, which is required to make an association amongst system and developer, the product which is utilized here to send set of instructions to the equipment

(Arduino Yun Board) is Arduino IDE which have an outline where coder can write their code and actualize on the Arduino Yun. So, in doing as such we have few steps to follow:

- Install Arduino IDE
- Connect Arduino Board
- Apply the power supply
- Connect the Arduino Yun board with serial connections using USB cable.
- Run the required sketch required
- Wait for the response.
- Go to CoolTerm
- Capture the serial data using capture option
- Store the data into .csv format in dropbox
- Connect the dropbox to the front-end webpage.

3.4 Working of the System

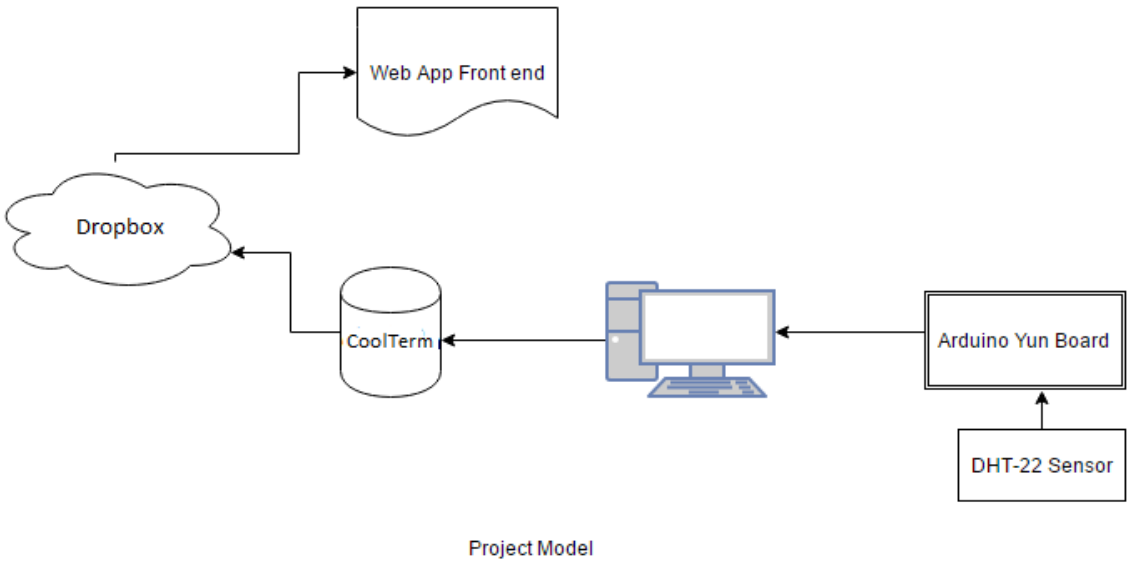

Figure 8 - Working of System

In this project, we have to collect the real-time environmental data in the dropbox and display the readings on the front-end webpage. In the designed system, we have to connect the

Arduino Yun board and the DHT-22 Temperature & humidity sensor with the help of connecting wires and USB cable to the system. In the system after executing Arduino sketch on the Arduino IDE, we need to capture the data using the application CoolTerm. With the help of CoolTerm, data will be captured and stored directly in the dropbox drive. The data in the dropbox is stored in .csv format and we need to display the data on a front-end webpage using charts.

3.5 Data Collection

To collect the sensor data, we need to connect Arduino Yun board to DHT-22 sensor using connecting wires and connect it with a local system using USB cable. We need to write the DHT sensor code available in the examples of Arduino IDE and compile it. Following is the diagram of the sketch.

```
  dht.begin();
}

void loop() {
  // Wait a few seconds between measurements.
  delay(900000);

  // Reading temperature or humidity takes about 15min!
  // Sensor readings may also be up to 2 seconds 'old' (its a very slow sensor)
  float h = dht.readHumidity();
  // Read temperature as Celsius (the default)
  float t = dht.readTemperature();

  // Check if any reads failed and exit early (to try again).
  if (isnan(h) || isnan(t)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }


  Serial.print("Humidity: ");
  Serial.print(h);
  Serial.print(" %\t");
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.print(" *C\n ");
   }
```

Figure 9 - DHT22 Sketch

We need to collect the data for day, afternoon and evening for 10 mins each day.

Before compiling we need to check for some settings. As shown in the below diagrams we need to set board as Arduino Yun and port on COM port where Arduino board is available.

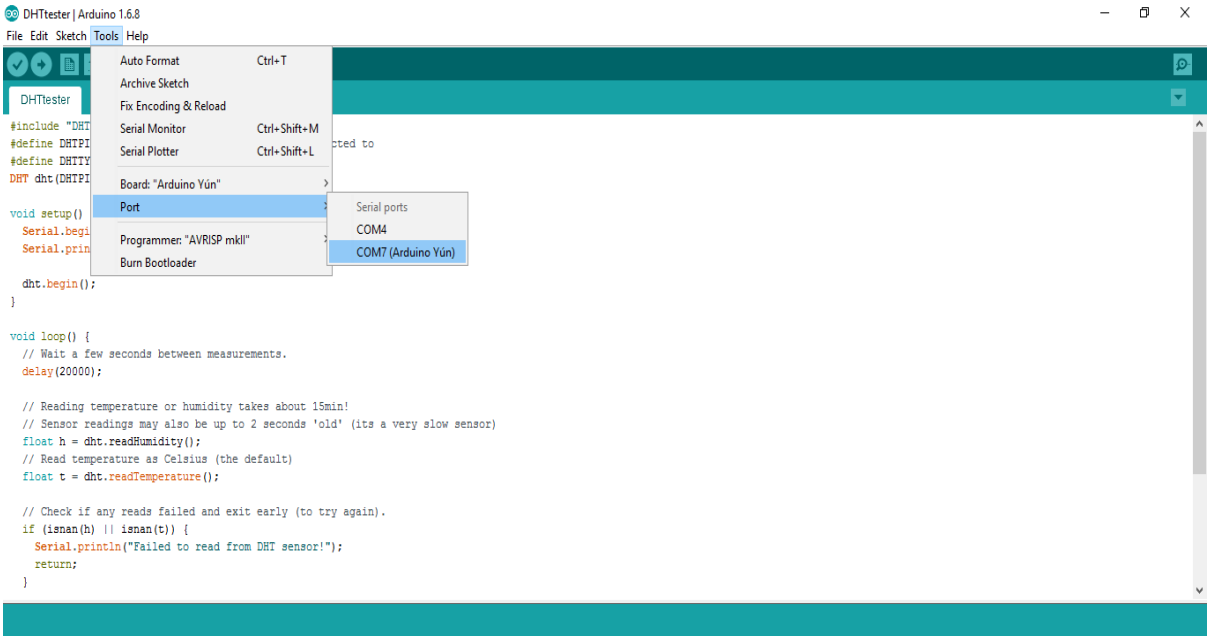

Figure 10 - Selection of Port

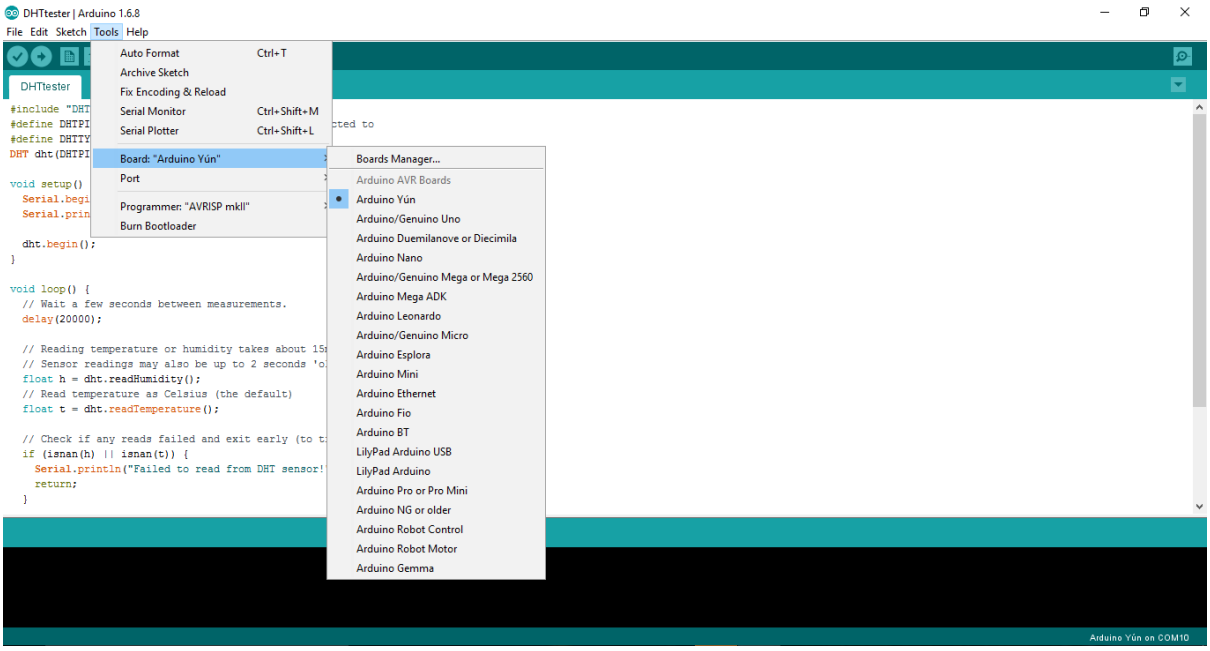

Figure 11 - Selection of Board

After we compile the code, we need to go to CoolTerm application where we will capture the data. Below in the diagram, serial connections are explained of CoolTerm.

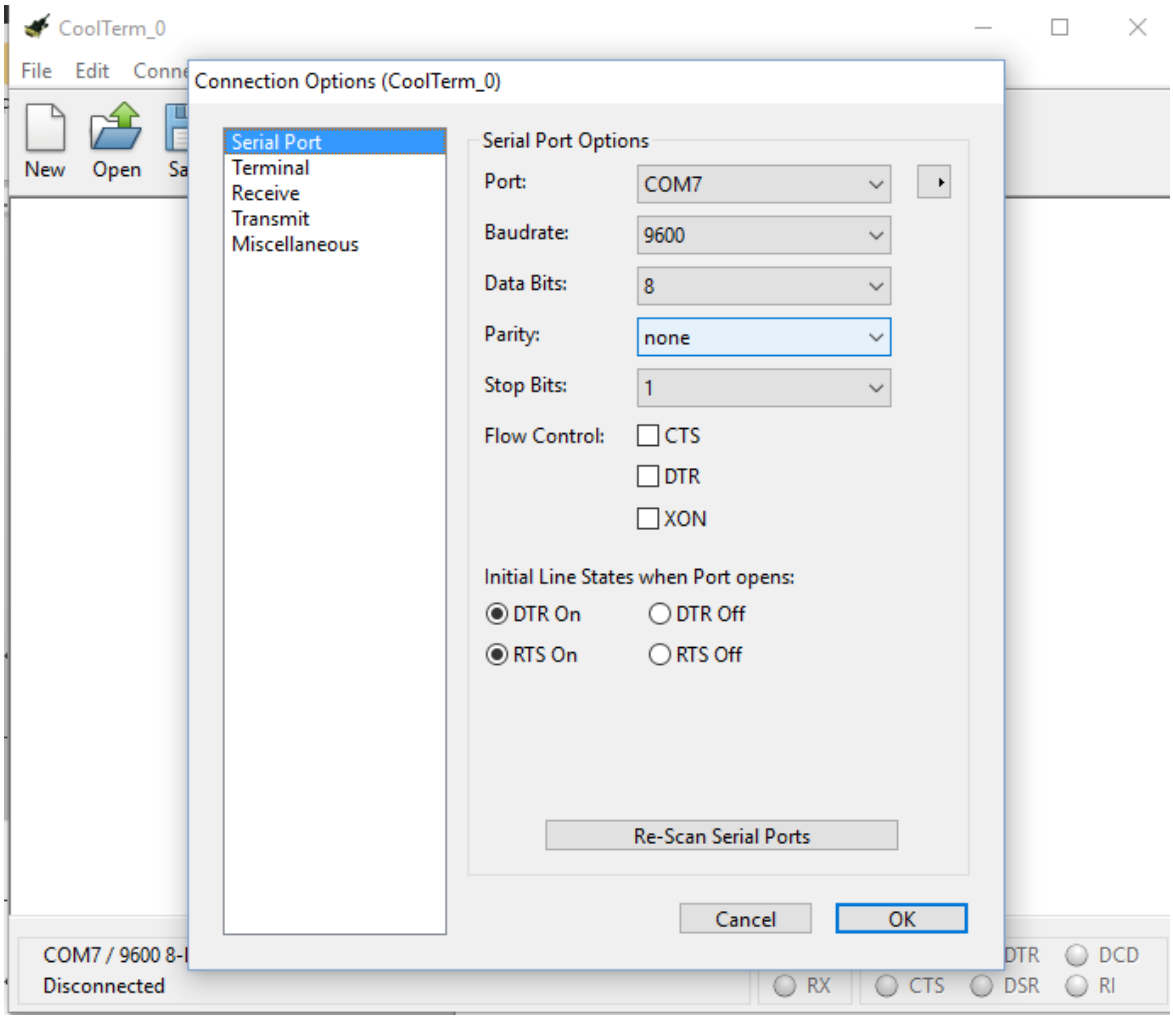

Figure 12 - CoolTerm Specifications

3.6 Data Visualization

The data collected in CoolTerm will be saved on Dropbox drive. The diagrams are better explained in the result section. Web Browsers through localhost, which demonstrates the temperature and humidity as a website page. We have utilized HTML, PHP and MySQL to acquire that information and elaborated it on website page through the assistance of web server which shows the front-end webpage on localhost with the help of webpage.

Chapter – 4

Results -

This section relates with the results that are obtained, after the implementation of the above-mentioned framework. As we go through the whole process we come across number of important results. All the results along with its description are discussed in this section.

The Arduino Yun board is connected to the DHT22 sensor and COM port using the connecting wires and USB cables respectively. As the DHT Sensor sketch is compiled and uploaded to the Arduino Yun board, the output for it is obtained and is shown on the Serial Monitor of the COM7. The Serial monitor represents the humidity and temperature data in percentage and degree Celsius respectively. Its screenshot is shown below –

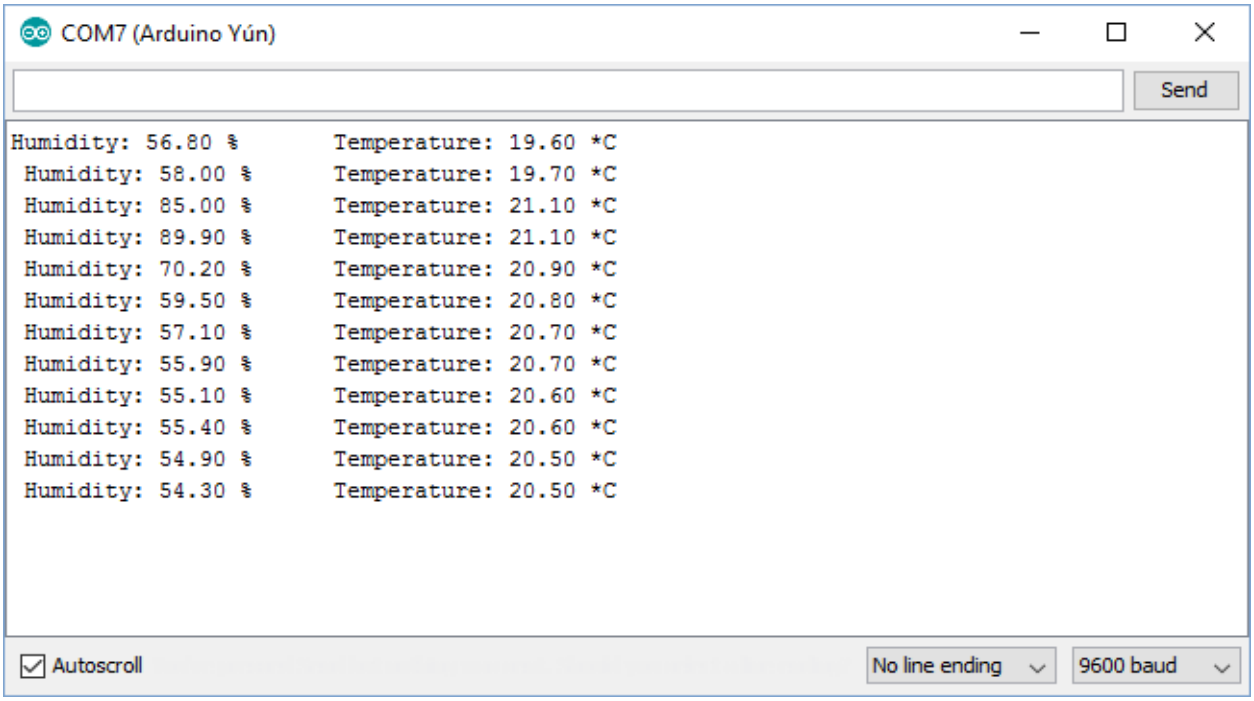

Figure 13 - Arduino Serial monitor

As discussed in the system design and working that the serial monitor is connected to the third-party software Cool Term. So, as we get results on the Serial monitor of the Arduino Yun board, at the same time we get the readings on cool Term window. The screenshot is with Cool Term showing readings is shown below –

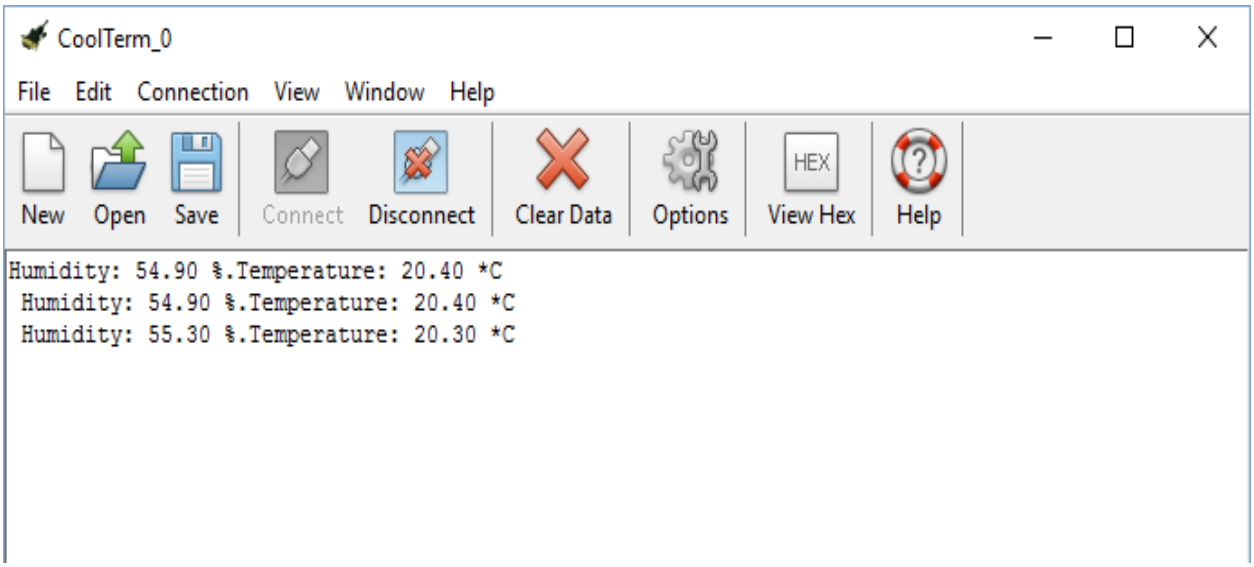

Figure 14 - Data Collection in CoolTerm

It is clear from the above screenshot that the Cool Term also shows the temperature and humidity data that is measured in Celsius and percentage respectively. The sensor measures the data periodically.

The next objective of our project is to capture the sensor output in .csv file. This is done by clicking on the 'connection' tab of Cool Term and then click on 'Capture to Textfile' and click 'Start'. This will automatically capture the data to the .csv file and we can name the file as 'Readings'. Below is the process and result for this step -

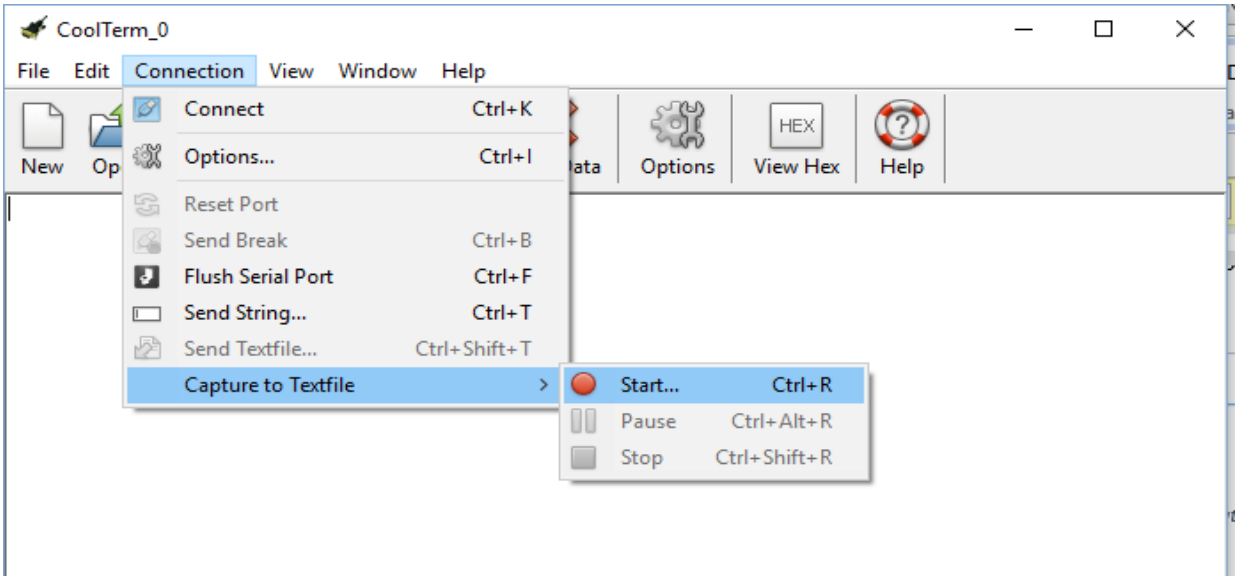

Figure 15 - Capturing Data in File

The screenshot for reading is shown –

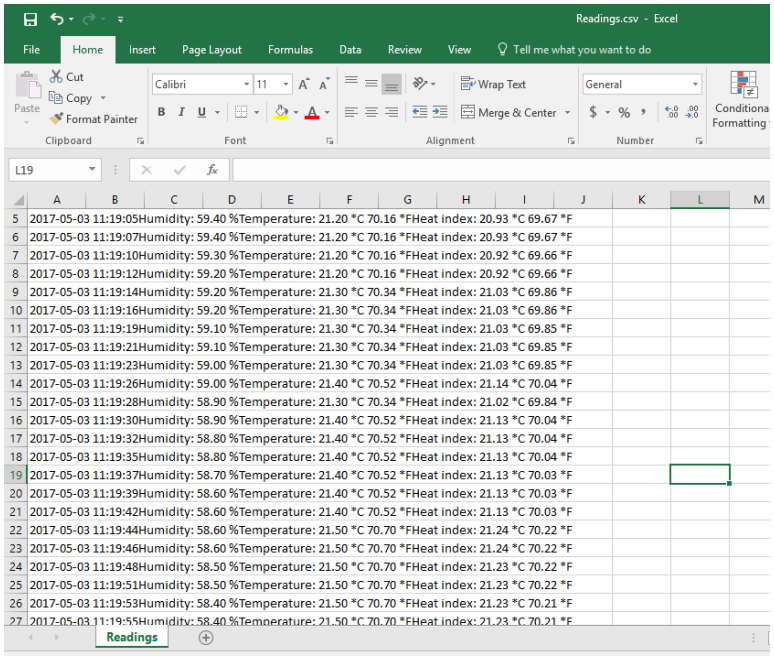

Figure 16 - .CSV File Consisting of Readings

The last result is related to uploading the data on Dropbox. As we capture these readings to this file, this file is uploaded to the Dropbox. The screenshot is shown below –

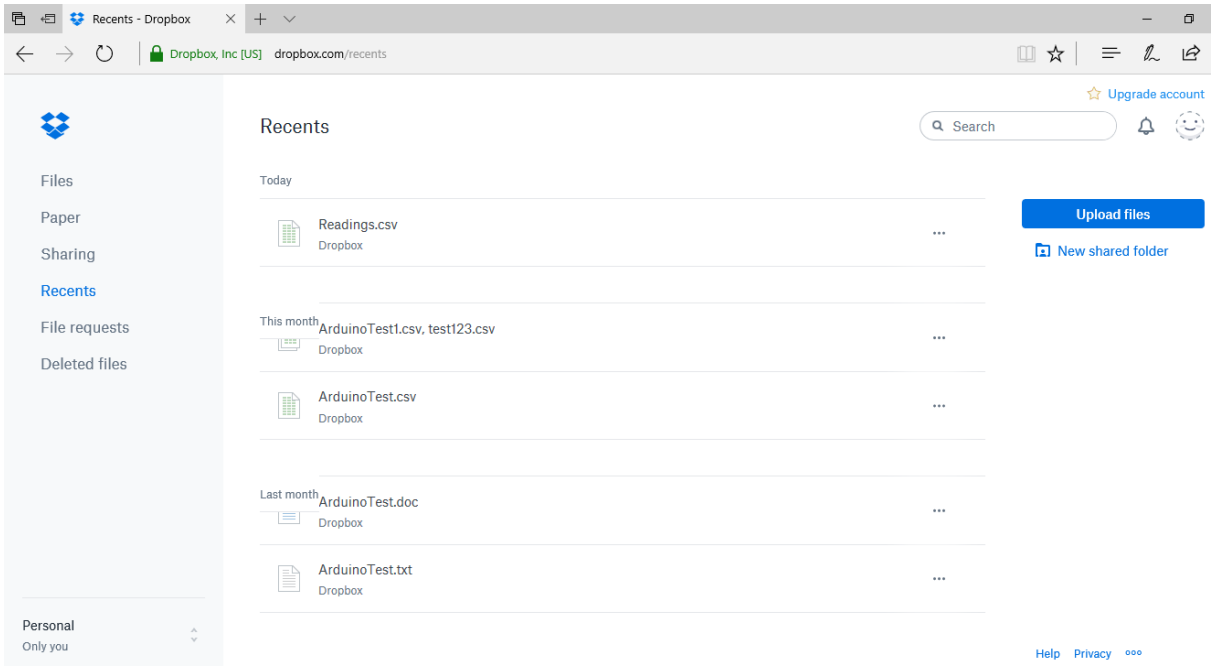

Figure 17 - Reading.CSV File uploaded to Dropbox

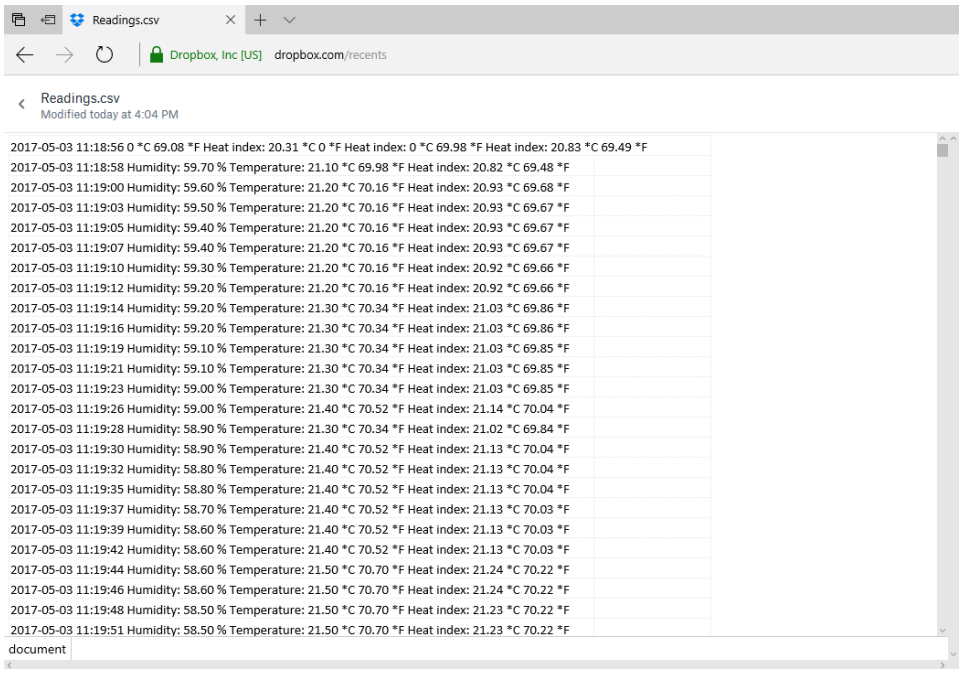

Figure 18 - File showing the Readings

These reading are then represented via a webpage.

Chapter 5 –

Problem analysis –

This part of the assignment deals with the analysis of the problems that were discussed earlier.

Research Question 1 – Identification of apt data collection tool

As discussed before, to record data from Arduino board is a colossal task and in this scenario, the Arduino is to be connected to the sensor and then is to be connected to google cloud platform, i.e. Dropbox. After some research, I found 'Temboo web service' as the primary solution for this problem. Additionally, Temboo service can be connected to the IoT devices such as Arduino.

But it also has some problem, that it provides the user with few free trails and after that it costs some money to utilize this service. Also, every time we connect Arduino to Temboo, we need to build new Choreo to make our application run and to record the data. Moreover, for every Choreo there is need of a particular code that should relate to the Arduino and sensor in order to upload the data wirelessly.

This problem was overcome by using a simple data collection tool known as CoolTerm which is free software that can capture Arduino sensor data efficiently and can also convert to text file or .csv file. These features of CoolTerm are very useful which hardly created any obstructions to the system.

Research Question 2 – Connecting Arduino board wirelessly

Wireless connection of Arduino is required in this proposed framework in order to upload the data to Dropbox. But connecting Arduino wirelessly can be a problem as it needs few authentication steps and some proxy settings. This problem was solved by simply following the steps to connect Arduino Yun wirelessly. This information is given on the Arduino Yun website. Initially, we have to reset the WLAN for Arduino, then search for a new connection. Also, if the Arduino board is connected wirelessly, there is need of establishing SSL connection between Arduino board and the network which can be done by using Linux for Arduino Yun board.

Research Question 3 – Applying programing techniques on Arduino

For some basic Arduino projects, we don't require prior programming knowledge. To get the readings in google cloud we need to modify the Arduino sketch with logic and programming script. As Arduino

related programming is done is Arduino IDE and is written in C language. So, the person needs to have strong programming skills in C language.

Research Question 4 – Choosing external storage device on Arduino to store data-

To mount a large amount of data on Arduino, sometimes we need external storage device. Hence SD memory card can be a good option. It comes with larger memory space and long lasting life. Arduino board consists of a memory card slot. But it simply adds up to the hardware requirement for the project. So, we chose Dropbox which is free and allows around 2GB of space for data storage.

5.1 Limitations –

Whenever a research is carried out, it has both advantages and disadvantages related to it. Similarly, our research has some limitations which will be discussed in this section. One limitation is that we could use the Arduino Shields such as WIFI or Ethernet to directly transfer the data to the Dropbox. For those purposes, every time we use Arduino we need to connect it with WIFI or Ethernet to make best use of it. Also, with this method we will be able to directly get the value from the sensor using GET method and display the sensor value using POST command. So, if we would have utilized any of the above-mentioned shields, it would have been easy to collect the data.

Chapter – 6 –

Conclusions and Future Research –

This project of Cloud connected IoT is a low-budget framework which has been developed to attain accuracy and precision in the practice of measuring temperature and humidity data and display it on the webpage. This framework is capable of measuring temperature and humidity at equal intervals and the readings are quite accurate. It has many other additional features such as portability and small size. Due to its small size, it does not really capture much of space. Also, this framework takes very less time to configure. Moreover, installation process is small. Another advantage is that it is not expensive to purchase. If the comparison is done among this system and the frameworks discussed in the literature review, this system needs less investment. At the same time, it is helpful in providing accurate data. Also, less hardware is required to execute this project as only Arduino Yun and DHT22 sensor is used.

Moreover, this framework has some additional versatile features. It displays the temperature and humidity related information on the webpage which can be accessed via PC, mobile phone or tablet. This data, that is retrieved from sensor and displayed in form of webpage can be used to display useful data on official website of Deakin University.

Although this project is capable of recording the weather accurately in local areas only. It cannot be used to record weather data for wide range of areas as of now which makes the system useful for precise readings for smaller rage of areas. In order to deploy it for large area, there is requirement of inter-connecting the devices multiple times to record the weather data for large range of areas which is the topic for future research. The future research will also include the basis on which the Arduino devices will be connected.

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